Table S1. The design of the experiments and results for Ofloxacin, Tetracycline, and Sulfadiazine removal efficiency.

Run	Actual level of factors					Responses removal efficiency (%)		
	X_1	X_2	X_3	X_4	X_5	Ofloxacin	Tetracycline	Sulfadiazine
1	7.6	33.69	32.53	10.09	29.86	90.16	91.91	78.78
2	6	40.00	52.50	14.50	22.50	75.13	77.04	65.76
3	4.3	46.31	72.47	10.09	15.14	55.26	57.10	48.36
4	6	40.00	52.50	14.50	22.50	75.21	77.18	65.87
5	6	40.00	52.50	14.50	5.00	66.17	67.98	57.88
6	7.6	33.69	72.47	10.09	29.86	70.19	72.01	61.42
7	7.6	33.69	72.47	18.91	15.14	67.24	69.08	58.86
8	6	40.00	52.50	14.50	40.00	83.67	85.42	73.10
9	2	40.00	52.50	14.50	22.50	55.37	56.17	54.37
10	7.6	46.31	72.47	18.91	29.86	70.40	72.22	61.60
11	6	40.00	52.50	14.50	22.50	74.96	76.77	65.55
12	6	40.00	52.50	25.00	22.50	80.17	81.93	70.06
13	7.6	46.31	32.53	18.91	15.14	83.01	84.79	72.57
14	6	25.00	52.50	14.50	22.50	79.01	81.68	69.84
15	4.3	33.69	72.47	18.91	29.86	71.24	73.01	62.26
16	7.6	46.31	72.47	10.09	29.86	65.98	67.83	57.76
17	7.6	33.69	72.47	10.09	15.14	62.83	64.69	55.02
18	7.6	46.31	72.47	18.91	15.14	63.04	64.89	55.20
19	4.3	33.69	72.47	18.91	15.14	63.88	65.68	55.86
20	4.3	33.69	72.47	10.09	15.14	59.47	61.28	52.02
21	7.6	46.31	72.47	10.09	15.14	58.62	60.50	51.36
22	4.3	33.69	32.53	18.91	15.14	83.85	85.57	73.23
23	6	40.00	52.50	14.50	22.50	75.17	77.11	65.82
24	10	40.00	52.50	14.50	22.50	73.22	74.26	63.48
25	4.3	46.31	72.47	10.09	29.86	62.62	64.43	54.76
26	6	40.00	52.50	4.00	22.50	69.67	71.47	60.93
27	6	40.00	52.50	14.50	22.50	75.26	77.25	65.93
28	7.6	33.69	72.47	18.91	29.86	74.60	76.41	65.26
29	4.3	33.69	32.53	10.09	15.14	79.44	81.18	69.39
30	7.6	46.31	32.53	18.91	29.86	90.37	92.11	78.97
31	4.3	46.31	32.53	10.09	29.86	82.59	84.32	72.13
32	7.6	33.69	32.53	18.91	15.14	87.21	88.97	76.22
33	4.3	33.69	32.53	18.91	29.86	91.21	92.90	79.62
34	4.3	46.31	32.53	18.91	15.14	79.65	81.39	69.57
35	6	40.00	5.00	14.50	22.50	98.67	99.37	86.14
36	7.6	46.31	32.53	10.09	15.14	78.60	80.39	68.73
37	6	55.00	52.50	14.50	22.50	69.18	71.72	61.14
38	7.6	33.69	32.53	18.91	29.86	94.57	96.30	82.62
39	4.3	46.31	32.53	18.91	29.86	87.00	88.71	75.97
40	6	40.00	52.50	14.50	22.50	75.00	76.84	65.60
41	4.3	33.69	72.47	10.09	29.86	66.82	68.61	58.42
42	6	40.00	100	14.50	22.50	51.17	53.04	44.84
43	7.6	33.69	32.53	10.09	15.14	82.80	84.58	72.38

44	4.3	46.31	32.53	10.09	15.14	75.23	76.99	65.73
45	7.6	46.31	32.53	10.09	29.86	85.95	87.72	75.13
46	6	40.00	52.50	14.50	22.50	75.04	76.90	65.66
47	4.3	33.69	32.53	10.09	29.86	86.79	88.51	75.78
48	4.3	46.31	72.47	18.91	29.86	67.03	68.82	58.60
49	4.3	46.31	72.47	18.91	15.14	59.68	61.49	52.20
50	6	40.00	52.50	14.50	22.50	75.09	76.97	65.71

Table S2. ANOVA for response surface quadratic model for Ofloxacin removal efficiency.

	Sum of Squares	**Degree of freedom**	**Mean Square**	**F-value**	**p-value**	
Model	19.39	20	0.9693	96.07	< 0.0001	significant
X_1	0.7736	1	0.7736	76.67	< 0.0001	
X_2	0.643	1	0.643	63.73	< 0.0001	
X_3	14.6	1	14.6	1446.82	< 0.0001	
X_4	0.7132	1	0.7132	70.69	< 0.0001	
X_5	1.98	1	1.98	196.35	< 0.0001	
X_1X_2	0.0001	1	0.0001	0.0064	0.9368	
X_1X_3	0.0014	1	0.0014	0.1383	0.7127	
X_1X_4	0.0001	1	0.0001	0.0071	0.9336	
X_1X_5	0.0002	1	0.0002	0.0195	0.8899	
X_2X_3	0.0022	1	0.0022	0.2159	0.6457	
X_2X_4	0.0001	1	0.0001	0.011	0.9171	
X_2X_5	0.0003	1	0.0003	0.0305	0.8627	
X_3X_4	0.0024	1	0.0024	0.2379	0.6294	
X_3X_5	0.0066	1	0.0066	0.6582	0.4238	
X_4X_5	0.0003	1	0.0003	0.0336	0.8559	
X_1^2	0.596	1	0.596	59.07	< 0.0001	
X_2^2	0.0006	1	0.0006	0.0595	0.8089	
X_3^2	0.003	1	0.003	0.2977	0.5895	
X_4^2	0.0074	1	0.0074	0.7369	0.3977	
X_5^2	0.0054	1	0.0054	0.5385	0.469	
Residual	0.2926	29	0.0101			
Lack of Fit	0.2923	22	0.0133	368.37	< 0.0001	significant
Pure Error	0.0003	7	0			
Cor Total	19.68	49				

Table S3. ANOVA for response surface quadratic model for Tetracycline removal efficiency.

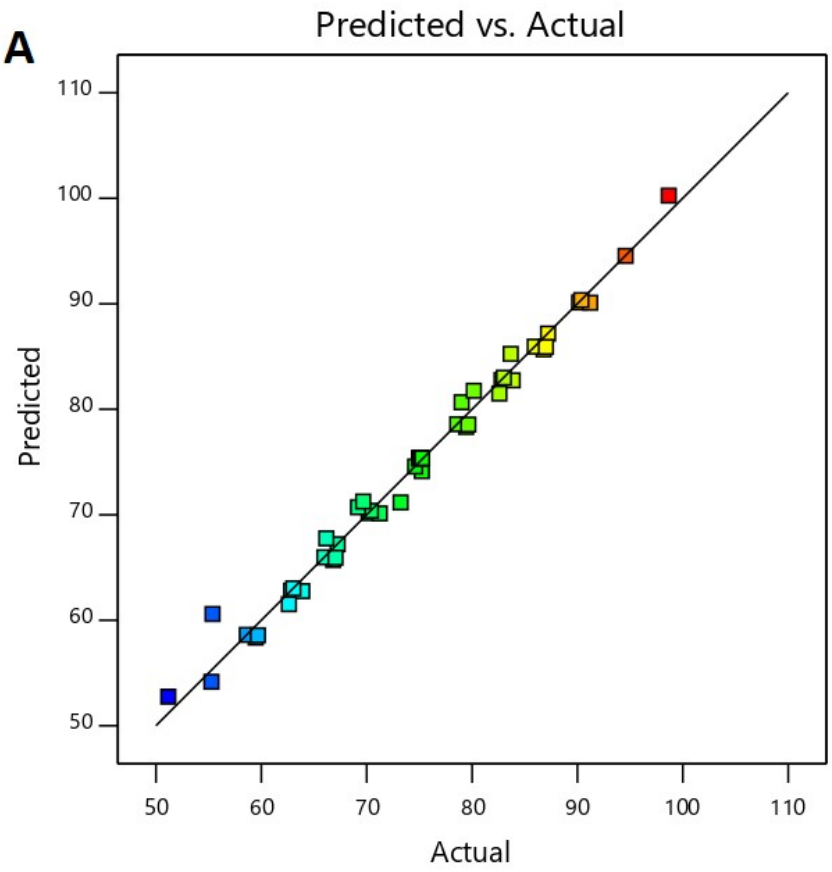
	Sum of Squares	**Degree of freedom**	**Mean Square**	**F-value**	**p-value**	
Model	18.81	20	0.9407	89.78	< 0.0001	significant
X_1	0.7769	1	0.7769	74.14	< 0.0001	
X_2	0.6264	1	0.6264	59.78	< 0.0001	
X_3	14	1	14	1336.2	< 0.0001	
X_4	0.6906	1	0.6906	65.91	< 0.0001	
X_5	1.92	1	1.92	183.08	< 0.0001	
X_1X_2	0.0001	1	0.0001	0.0058	0.9398	
X_1X_3	0.0013	1	0.0013	0.1255	0.7257	
X_1X_4	0.0001	1	0.0001	0.0064	0.9368	
X_1X_5	0.0002	1	0.0002	0.0177	0.8951	
X_2X_3	0.002	1	0.002	0.1902	0.666	
X_2X_4	0.0001	1	0.0001	0.0097	0.9223	
X_2X_5	0.0003	1	0.0003	0.0268	0.8711	
X_3X_4	0.0022	1	0.0022	0.2097	0.6504	
X_3X_5	0.0061	1	0.0061	0.5802	0.4524	
X_4X_5	0.0003	1	0.0003	0.0295	0.8648	
X_1^2	0.7013	1	0.7013	66.93	< 0.0001	
X_2^2	0.0066	1	0.0066	0.6334	0.4326	
X_3^2	0.0075	1	0.0075	0.7155	0.4046	
X_4^2	0.0065	1	0.0065	0.6237	0.4361	
X_5^2	0.0047	1	0.0047	0.4524	0.5065	
Residual	0.3039	29	0.0105			
Lack of Fit	0.3032	22	0.0138	151.91	< 0.0001	significant
Pure Error	0.0006	7	0.0001			
Cor Total	19.12	49				

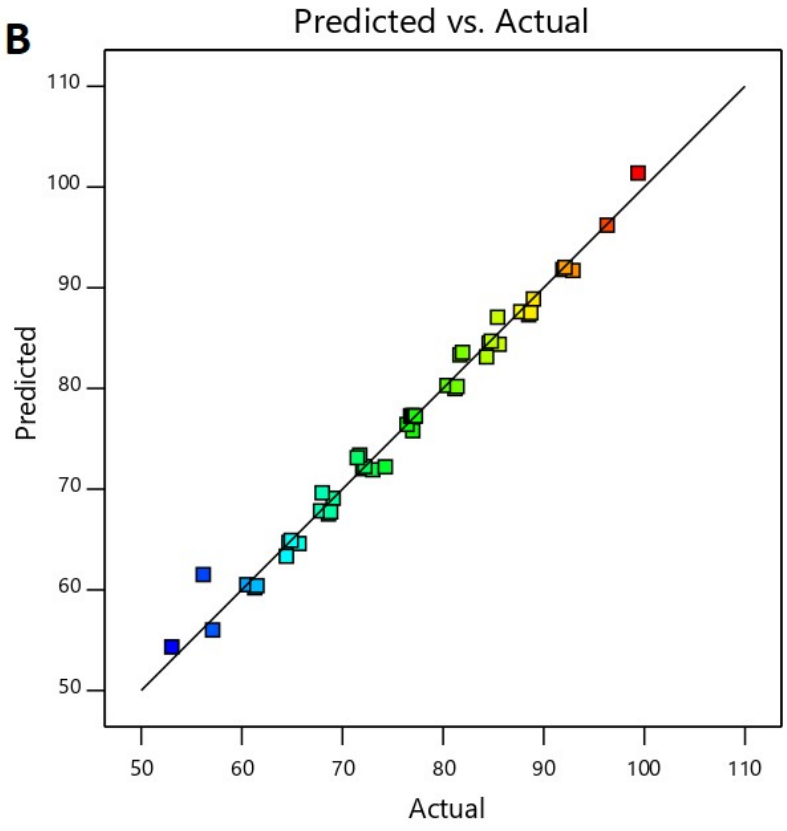
Table S4. ANOVA for response surface quadratic model for Sulfadiazine removal efficiency.

	Sum of Squares	**Degree of freedom**	**Mean Square**	**F-value**	**p-value**	
Model	16.26	20	0.8132	416.82	< 0.0001	significant
X_1	0.447	1	0.447	229.12	< 0.0001	
X_2	0.5595	1	0.5595	286.76	< 0.0001	
X_3	12.62	1	12.62	6470.7	< 0.0001	
X_4	0.6168	1	0.6168	316.16	< 0.0001	
X_5	1.71	1	1.71	878.17	< 0.0001	
X_1X_2	0.0001	1	0.0001	0.0297	0.8643	
X_1X_3	0.0013	1	0.0013	0.6426	0.4293	
X_1X_4	0.0001	1	0.0001	0.0328	0.8576	
X_1X_5	0.0002	1	0.0002	0.0907	0.7655	
X_2X_3	0.0019	1	0.0019	0.955	0.3365	
X_2X_4	0.0001	1	0.0001	0.0487	0.8269	
X_2X_5	0.0003	1	0.0003	0.1347	0.7162	
X_3X_4	0.0021	1	0.0021	1.05	0.3134	
X_3X_5	0.0057	1	0.0057	2.91	0.0986	
X_4X_5	0.0003	1	0.0003	0.1485	0.7028	
X_1^2	0.2629	1	0.2629	134.75	< 0.0001	
X_2^2	0.0014	1	0.0014	0.7402	0.3967	
X_3^2	0.0087	1	0.0087	4.43	0.044	
X_4^2	0.0014	1	0.0014	0.7169	0.4041	
X_5^2	0.0007	1	0.0007	0.3416	0.5634	
Residual	0.0566	29	0.002			
Lack of Fit	0.0561	22	0.0026	37.98	< 0.0001	significant
Pure Error	0.0005	7	0.0001			
Cor Total	16.32	49				

Fig. S1a-c illustrate the relationship between the actual and predicted responses, displaying an almost linear trend with minor deviations. The normal probability plot of residuals in Fig. S2a-c is used as a diagnostic tool to evaluate the model's fit. A straight-line pattern in this plot suggests that the residuals (the differences between observed and predicted values) follow a normal distribution. This normality implies that the errors are uniformly distributed across the range of independent variables, supporting the appropriateness of the least squares fitting and indicating that the model effectively captures the relationship between the independent variables and the response. (Haghighizadeh et al., 2023).

Fig. S3a-c, which display residuals plotted against predicted responses and experimental runs, show that the residuals are randomly scattered above and below the x-axis, with no clear pattern. Despite this, the R^2 values for the models were 0.987, with adjusted R^2 and predicted R^2 values of 0.979 and 0.942, respectively, with a difference of less than 0.2. The accuracy and validity of the proposed models were further confirmed using analysis of variance (ANOVA). As shown in Tables S2-4, the models were highly significant, with F-values of 96.07, 89.78, and 416.82, and p-values below 0.0001. Therefore, these models are considered reliable for predicting outcomes and optimizing the parameters influencing antibiotic removal efficiency.


A
Predicted vs. Actual
Predicted
Actual
50
60
70
80
90
100
110


B
Predicted vs. Actual
Predicted
Actual
50
60
70
80
90
100
110

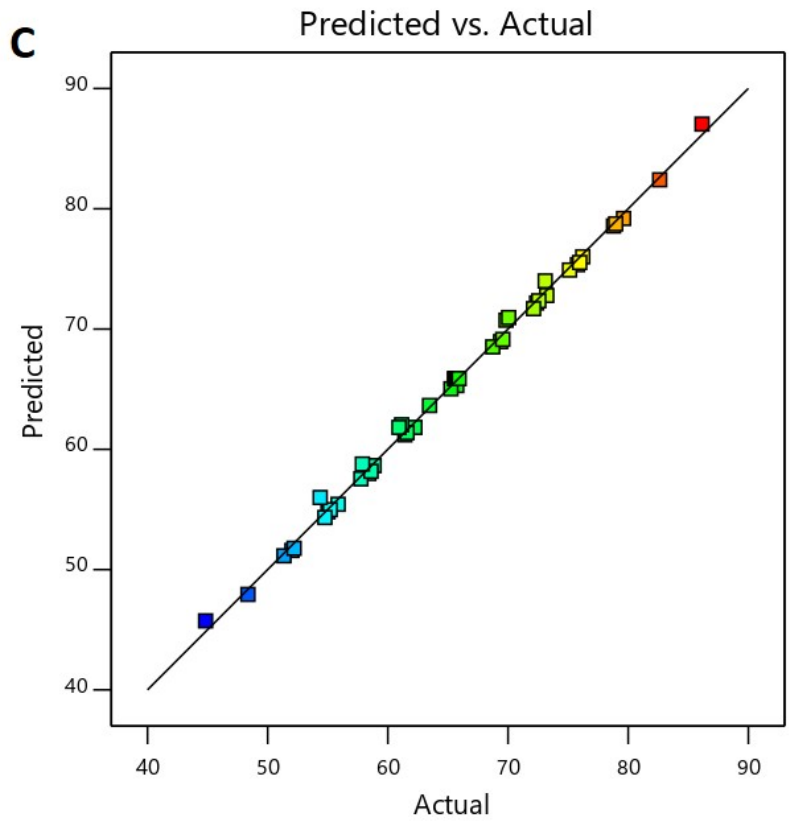
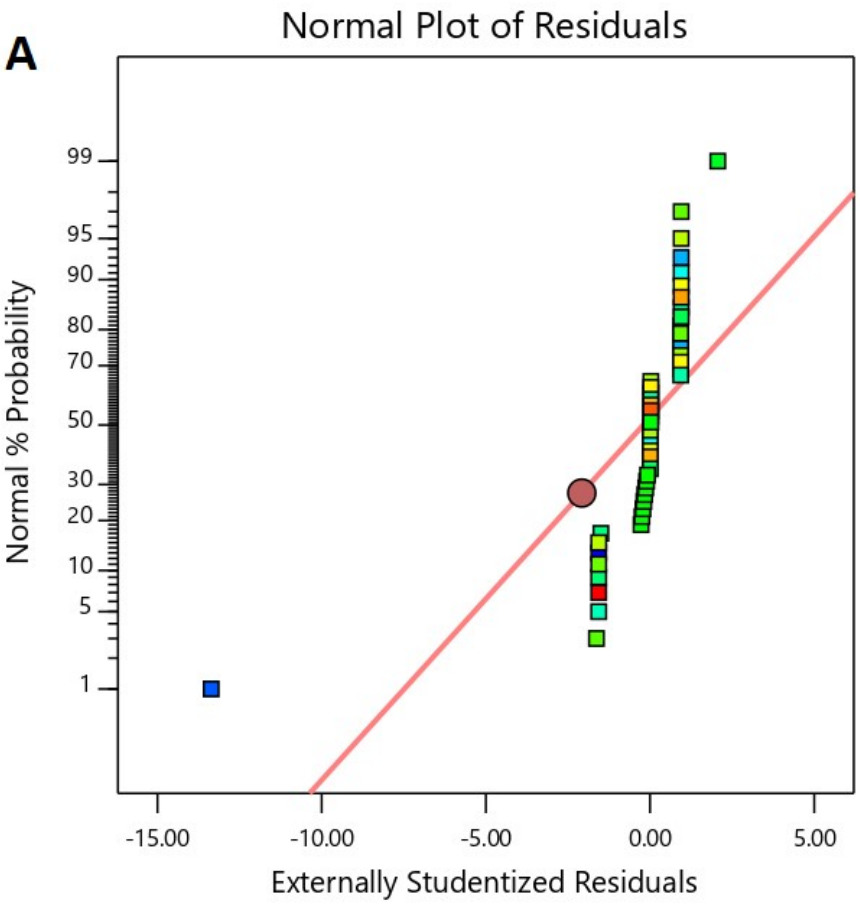
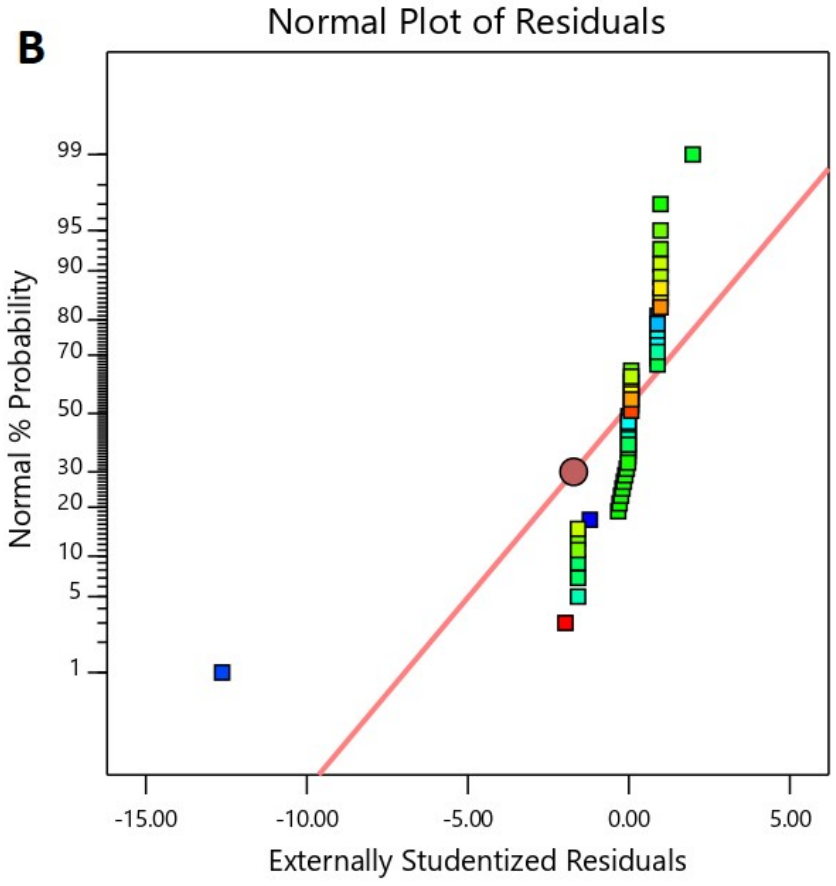


Fig. S1. Comparison of experimental and predicted responses $R\ (\%)$ for Ofloxacin (a), Tetracycline (b), and Sulfadiazine (c).


A
Normal Plot of Residuals
Normal % Probability
99
95
90
80
70
50
30
20
10
5
1
-15.00
-10.00
-5.00
0.00
5.00
Externally Studentized Residuals


B
Normal Plot of Residuals
Normal % Probability
99
95
90
80
70
50
30
20
10
5
1
-15.00
-10.00
-5.00
0.00
5.00
Externally Studentized Residuals

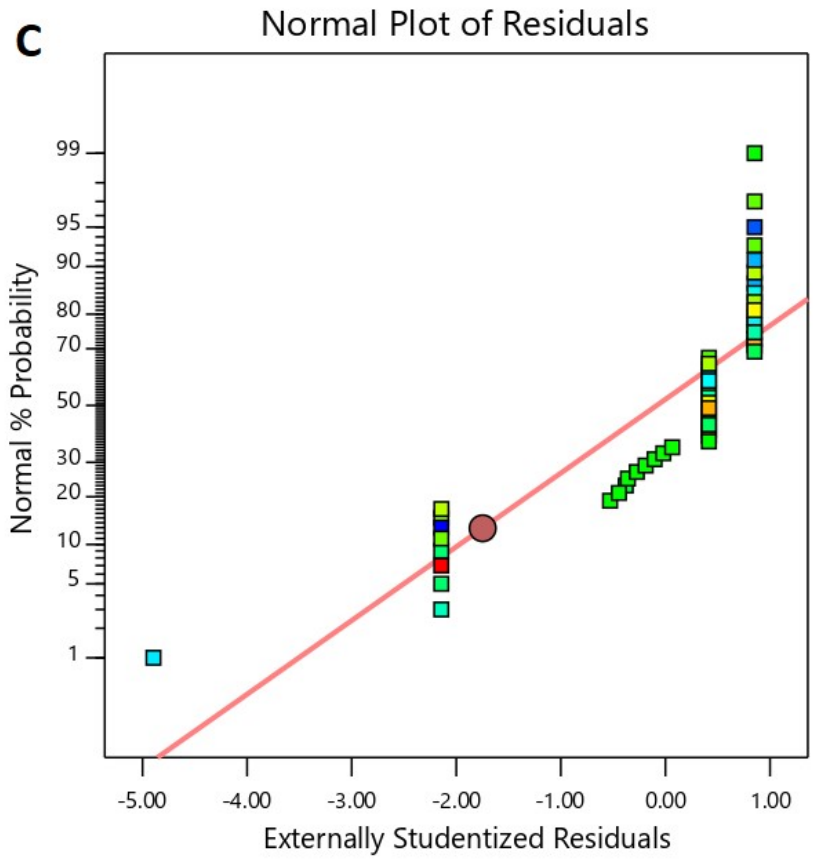
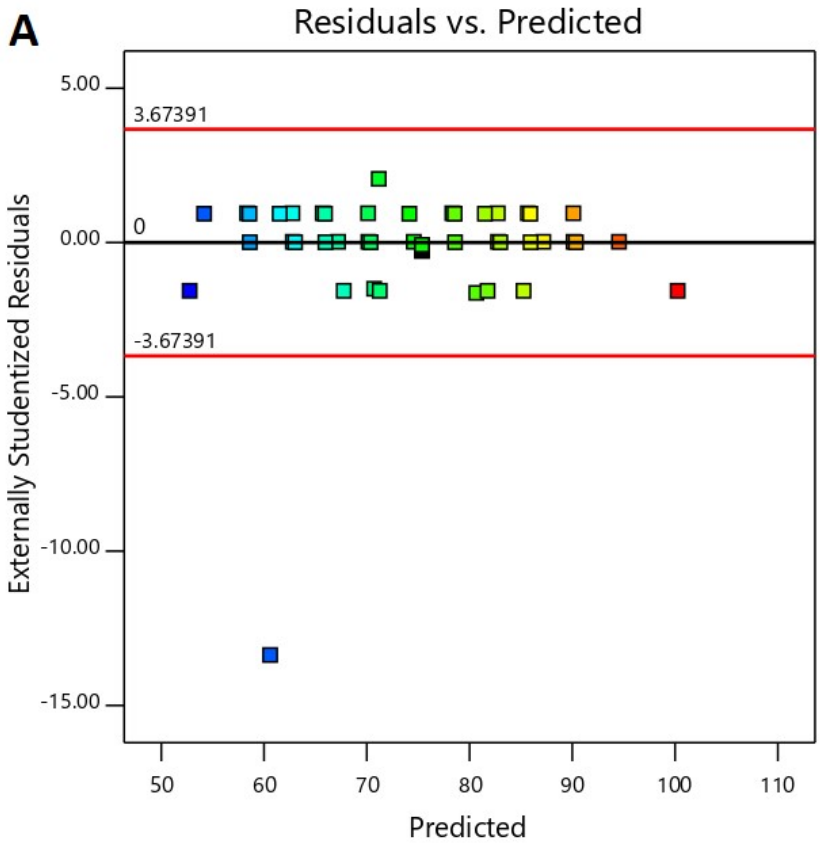
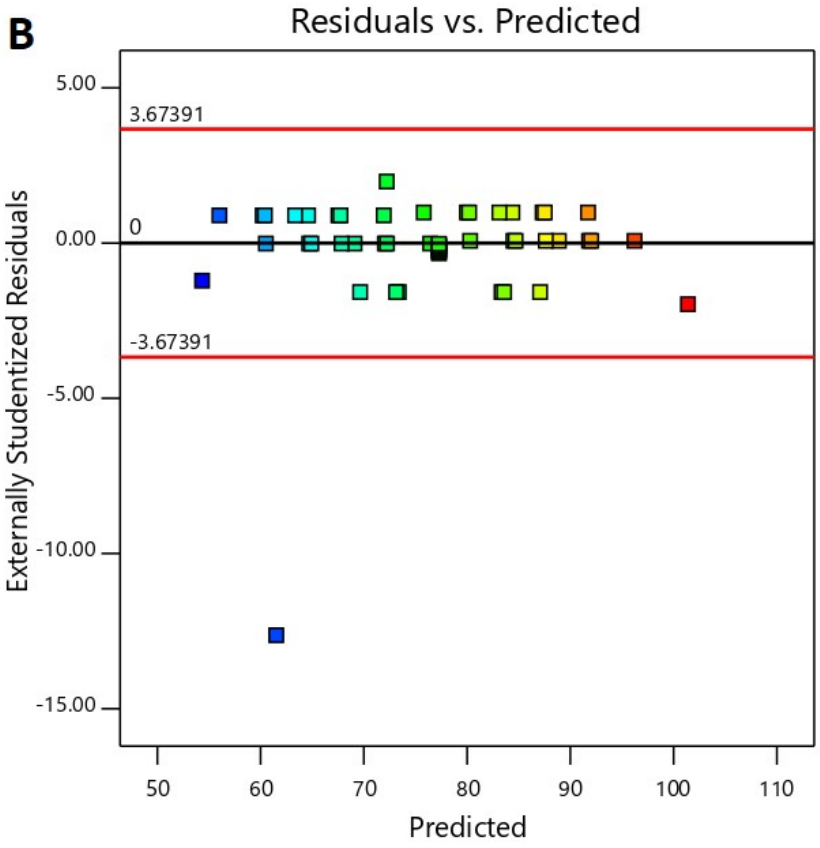


Fig. S2. Diagnostics and model graphs for removal efficiency normal plot of residuals for Ofloxacin (a), Tetracycline (b), and Sulfadiazine (c).


A
Residuals vs. Predicted
5.00
3.67391
0
0.00
-3.67391
-5.00
-10.00
-15.00
Externally Studentized Residuals
50
60
70
80
90
100
110
Predicted


B
Residuals vs. Predicted
5.00
3.67391
0
0.00
-3.67391
-5.00
-10.00
-15.00
Externally Studentized Residuals
50
60
70
80
90
100
110
Predicted

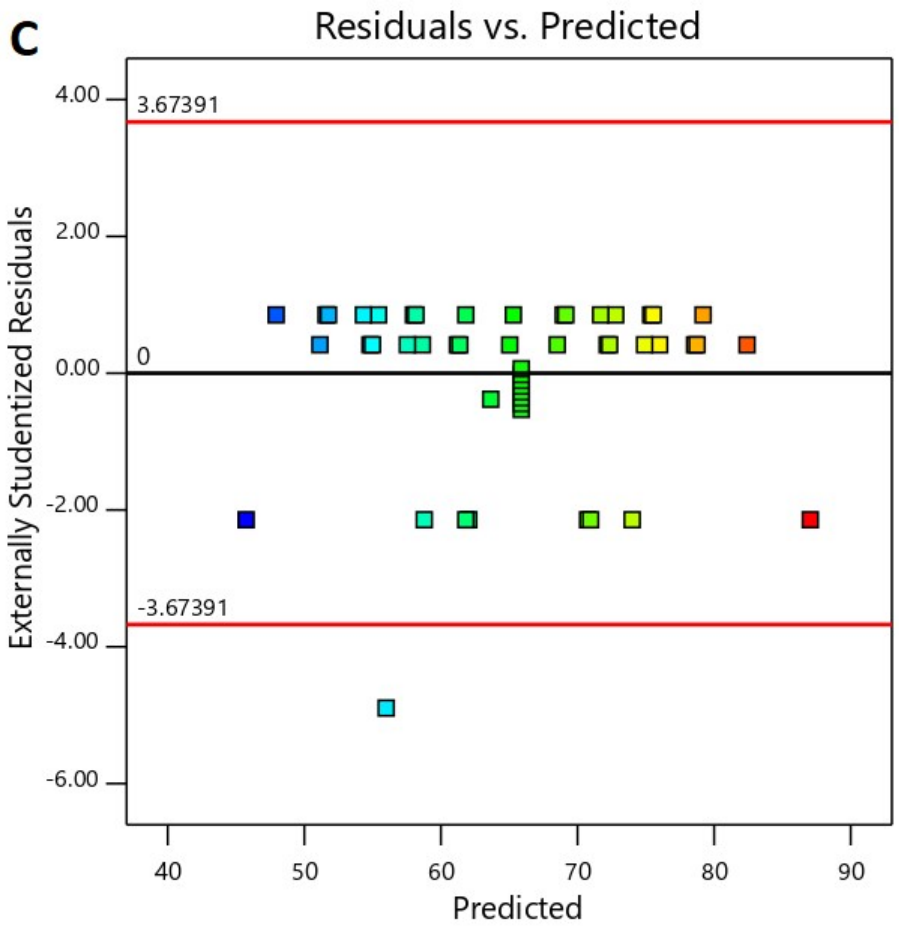
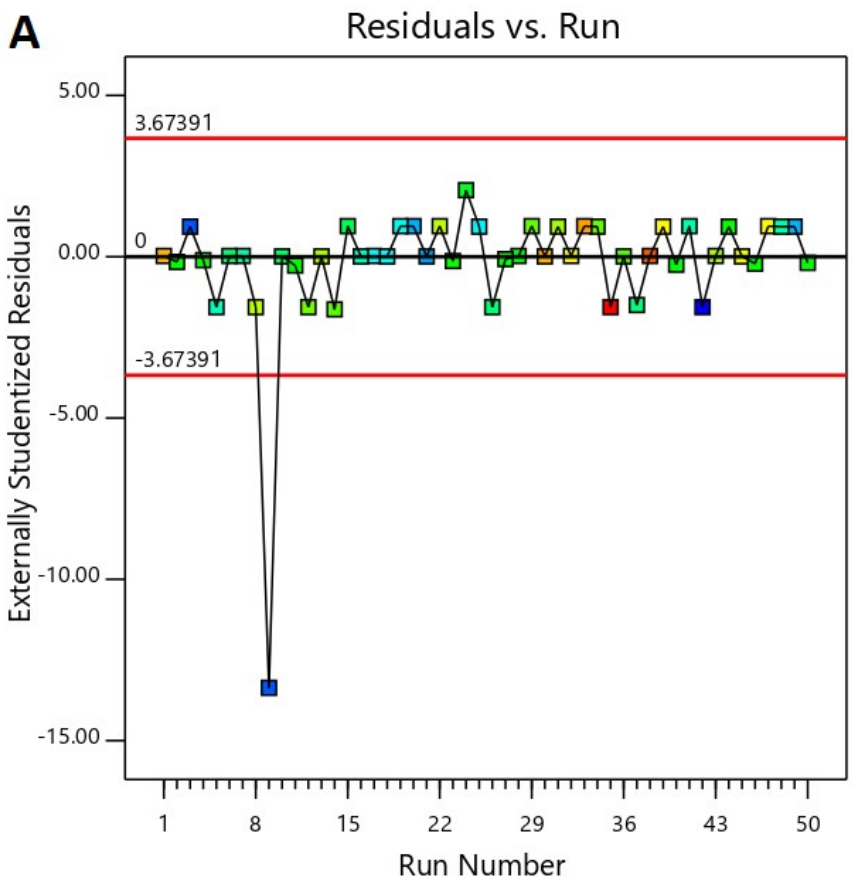
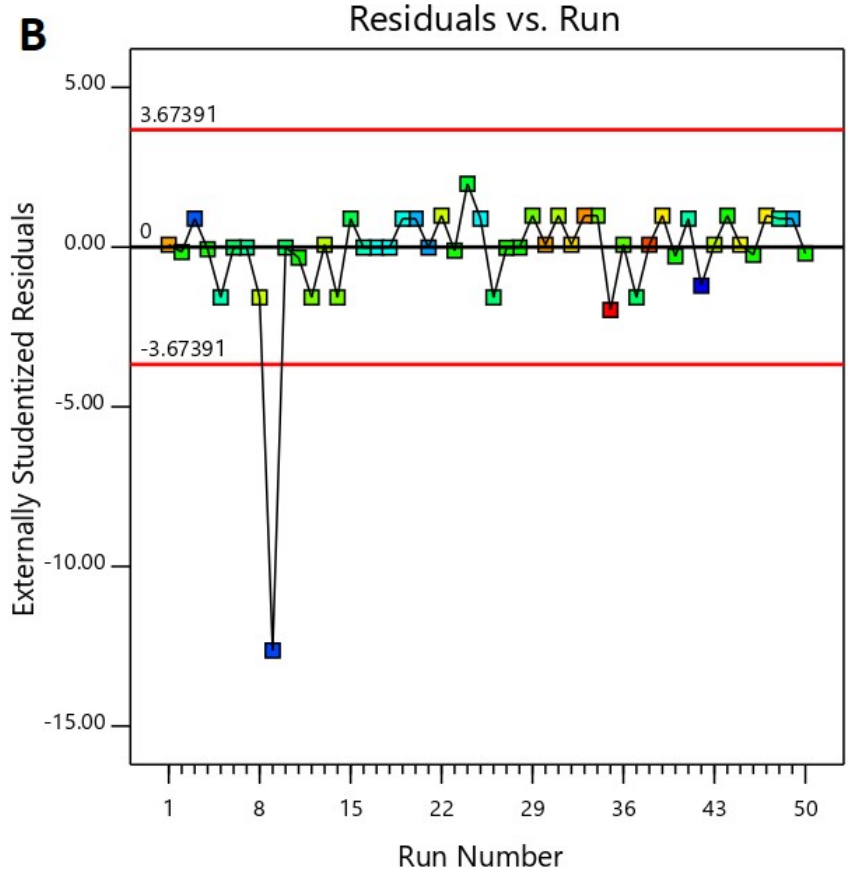


Fig. S3. Diagnostics and model graphs for removal efficiency residuals versus predicted of residuals for Ofloxacin (a), Tetracycline (b), and Sulfadiazine (c).


A
Residuals vs. Run
5.00
3.67391
0
0.00
-3.67391
-5.00
-10.00
-15.00
Externally Studentized Residuals
1
8
15
22
29
36
43
50
Run Number


B
Residuals vs. Run
5.00
3.67391
0
0.00
-3.67391
-5.00
-10.00
-15.00
Externally Studentized Residuals
1
8
15
22
29
36
43
50
Run Number

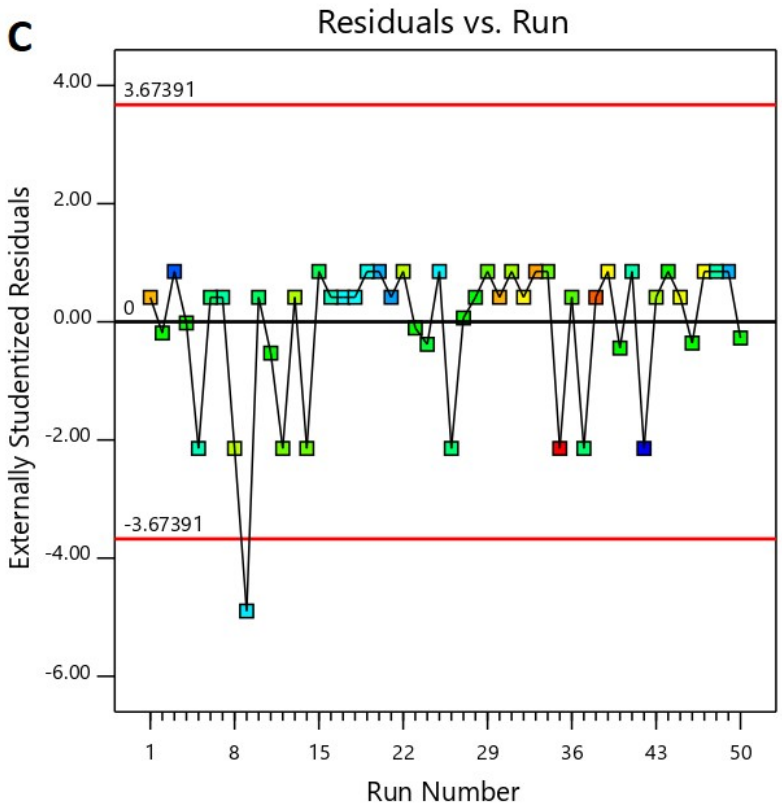


Fig. S4. Diagnostics and model graphs for removal efficiency residuals versus run numbers of residuals for Ofloxacin (a), Tetracycline (b), and Sulfadiazine (c).